

WHAT IS CLAIMED IS:

- 1        1. A network element operable in an Internet  
2        Protocol (IP) network, comprising:
  - 3                at least one terminating line card operable as  
4                an ingress card supporting an incoming communications  
5                link;
  - 6                at least one terminating line card operable as  
7                an egress card supporting an outgoing communications  
8                link;
  - 9                a switch fabric disposed between said ingress  
10          and egress cards for supporting a plurality of virtual  
11          ingress/egress pipes (VIEPs) therebetween, wherein said  
12          ingress and egress cards are provided with a plurality of  
13          buffer queues to support traffic flows associated with  
14          said VIEPs;
  - 15          a policing structure disposed on said ingress  
16          card for monitoring incoming traffic on said incoming  
17          communications link with respect to an expected traffic  
18          profile associated with said incoming traffic;
  - 19          a flow controller disposed on each of said  
20          ingress and egress cards, said flow controllers operating  
21          to manage said traffic flows associated with said VIEPs  
22          through said switch fabric, wherein said traffic flows  
23          are operable to be effectuated with resource reservations  
24          allocated in said switch fabric; and

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25                   a scheduler disposed on said egress card for  
26 scheduling and shaping outgoing traffic on said outgoing  
27 communications link.

1                 2. The network element operable in an IP network  
2 as set forth in claim 1, wherein said policing structure,  
3 said flow controllers, and said scheduler operate in  
4 concert with a plurality of counters associated with said  
5 ingress and egress cards to provide Quality of Service  
6 (QoS) parametric information necessary to effectuate a  
7 Service Level Agreement between a network service  
8 provider operating said network element and a subscriber  
9 for services available in said IP network.

1                 3. The network element operable in an IP network  
2 as set forth in claim 2, wherein each of said flow  
3 controllers is associated with at least one local  
4 congestion indicator, and further wherein each of said  
5 flow controllers operate in conjunction with a packet  
6 discarding mechanism for throttling flow on a particular  
7 VIEP.

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1           4. The network element operable in an IP network  
2       as set forth in claim 3, wherein said packet discarding  
3       mechanism associated with said flow controller on said  
4       ingress card is operable to be controlled at least in  
5       part by a feedback signal received from said at least one  
6       local congestion indicator disposed on said egress card.

1           5. The network element operable in an IP network  
2       as set forth in claim 3, wherein said plurality of buffer  
3       queues are categorized as one of real time (RT) and non-  
4       real time (NRT) queue types.

1           6. The network element operable in an IP network  
2       as set forth in claim 5, wherein said plurality of  
3       counters associated with said ingress card include a  
4       counter for monitoring the number of packets transferred  
5       per egress card per queue type.

1           7. The network element operable in an IP network  
2       as set forth in claim 5, wherein said plurality of  
3       counters associated with said ingress card include a  
4       counter for monitoring the number of bytes transferred  
5       per egress card per queue type.

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1           8. The network element operable in an IP network  
2 as set forth in claim 5, wherein said plurality of  
3 counters associated with said ingress card include a  
4 counter for monitoring the number of packets dropped per  
5 egress card per queue type.

1           9. The network element operable in an IP network  
2 as set forth in claim 5, wherein said plurality of  
3 counters associated with said ingress card include a  
4 counter for monitoring the number of bytes dropped per  
5 egress card per queue type.

1           10. The network element operable in an IP network  
2 as set forth in claim 5, wherein said QoS parametric  
3 information comprises traffic flow throughput information  
4 per Class of Service (CoS) per destination.

1           11. The network element operable in an IP network  
2 as set forth in claim 5, wherein said QoS parametric  
3 information comprises traffic loss ratio per Class of  
4 Service (CoS) per destination.

1           12. The network element operable in an IP network  
2 as set forth in claim 5, wherein said QoS parametric  
3 information comprises queuing delay information.

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1           13. The network element operable in an IP network  
2       as set forth in claim 12, wherein said queuing delay  
3       information comprises average depth of said buffer queues  
4       on said ingress and egress cards.

1           14. The network element operable in an IP network  
2       as set forth in claim 5, wherein said QoS parametric  
3       information comprises traffic flow jitter information.

1           15. The network element operable in an IP network  
2       as set forth in claim 14, wherein said wherein said QoS  
3       parametric information comprises available bandwidth per  
4       link.

1           16. The network element operable in an IP network  
2       as set forth in claim 5, wherein said plurality of  
3       counters associated with said egress card include a  
4       counter for monitoring the number of packets transmitted  
5       per egress card per queue type for each neighboring  
6       element associated with said network element in said IP  
7       network.

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1           17. The network element operable in an IP network  
2 as set forth in claim 5, wherein said plurality of  
3 counters associated with said egress card include a  
4 counter for monitoring the number of bytes transmitted  
5 per egress card per queue type for each neighboring  
6 element associated with said network element in said IP  
7 network.

1           18. The network element operable in an IP network  
2 as set forth in claim 5, wherein said plurality of  
3 counters associated with said egress card include a  
4 counter for monitoring the number of packets dropped per  
5 egress card per queue type for each neighboring element  
6 associated with said network element in said IP network.

1           19. The network element operable in an IP network  
2 as set forth in claim 5, wherein said plurality of  
3 counters associated with said egress card include a  
4 counter for monitoring the number of bytes dropped per  
5 egress card per queue type for each neighboring element  
6 associated with said network element in said IP network.

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1           20. The network element operable in an IP network  
2 as set forth in claim 5, wherein said plurality of  
3 counters associated with said egress card include a  
4 counter for monitoring average queue depth of said buffer  
5 queues per egress card.

1           21. The network element operable in an IP network  
2 as set forth in claim 5, wherein said plurality of  
3 counters associated with said egress card include a  
4 counter for monitoring the number of times a particular  
5 buffer queue crosses a packet discard threshold  
6 associated therewith.

1           22. A method for processing Quality of Service  
2        (QoS) parametric information in a network element  
3        operable in an Internet Protocol (IP) network, wherein  
4        said network element includes at least one terminating  
5        line card operable as an ingress card supporting an  
6        incoming communications link, at least one terminating  
7        line card operable as an egress card supporting an  
8        outgoing communications link and a switch fabric disposed  
9        between said ingress and egress cards for supporting a  
10      plurality of virtual ingress/egress pipes (VIEPs)  
11      therebetween, comprising the steps of:

12           receiving incoming information on said incoming  
13      link of said network element;

14           determining in an ingress portion a network  
15      processor system disposed on said ingress card whether  
16      said incoming information pertains to an IP-based  
17      service;

18           responsive to said determining step,  
19      propagating said incoming information to an egress  
20      portion of said network processor system via said switch  
21      fabric, said egress portion including an embedded  
22      processor operable to perform a plurality of IP-based QoS  
23      (IPQoS) monitoring operations and for processing said  
24      incoming information into processed information; and

25           transmitting said processed information to said  
26      egress card via a select VIEP for routing said processed  
27      information on said outgoing link to a neighbor in said  
28      network.

1           23. The method for processing QoS parametric  
2 information in a network element operable in an IP  
3 network as set forth in claim 22, wherein said IPQoS  
4 monitoring operations include policing said incoming  
5 information at said ingress card.

1           24. The method for processing QoS parametric  
2 information in a network element operable in an IP  
3 network as set forth in claim 23, wherein said policing  
4 step comprises measuring said incoming information  
5 against an expected behavior profile associated  
6 therewith.

1           25. The method for processing QoS parametric  
2 information in a network element operable in an IP  
3 network as set forth in claim 22, wherein said IPQoS  
4 monitoring operations include a plurality of flow control  
5 steps for effectuating bandwidth management for said  
6 switch fabric.

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1           26. A Quality of Service (QoS) monitoring system  
2 for a network element operable in an Internet Protocol  
3 (IP) network, wherein said network element includes at  
4 least one terminating line card operable as an ingress  
5 card for supporting an incoming communications link, at  
6 least one terminating line card operable as an egress  
7 card for supporting an outgoing communications link and  
8 a switch fabric disposed between said ingress and egress  
9 cards for supporting a plurality of virtual  
10 ingress/egress pipes (VIEPs) therebetween, comprising:

11                 a policing structure associated with said  
12 ingress card for monitoring incoming traffic on said  
13 incoming communications link with respect to an expected  
14 traffic profile associated with said incoming traffic;

15                 a buffer acceptance and flow control module  
16 associated with each of said ingress and egress cards,  
17 said buffer acceptance and flow control modules operating  
18 to manage traffic flows associated with said VIEPs  
19 through said switch fabric, wherein said traffic flows  
20 are operable to be effectuated with resource reservations  
21 allocated in said switch fabric; and

22                 a traffic shaping and scheduling module  
23 associated with said egress card for scheduling and  
24 shaping outgoing traffic on said outgoing communications  
25 link.

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1           27. The QoS monitoring system for a network element  
2 operable in an IP network as set forth in claim 26,  
3 wherein said policing structure, said buffer acceptance  
4 and flow control modules, and said traffic shaping and  
5 scheduling module operate in concert with a plurality of  
6 counters associated with said ingress and egress cards to  
7 provide QoS parametric information necessary to  
8 effectuate a Service Level Agreement between a network  
9 service provider operating said network element and a  
10 subscriber for services available in said IP network.

1           28. The QoS monitoring system for a network element  
2 operable in an IP network as set forth in claim 27,  
3 wherein each of said buffer acceptance and flow control  
4 modules is associated with a local congestion indicator  
5 for effectuating a packet discard mechanism to throttle  
6 buffers queues corresponding to said traffic flows in  
7 said switch fabric.

1           29. The QoS monitoring system for a network element  
2 operable in an IP network as set forth in claim 28,  
3 wherein said buffer acceptance and flow control module  
4 associated with said ingress card is operable to be  
5 controlled at least in part by a feedback control signal  
6 generated by said egress card's local congestion  
7 indicator.

1           30. The QoS monitoring system for a network element  
2 operable in an IP network as set forth in claim 29,  
3 wherein said feedback control signal comprises a per-flow  
4 congestion threshold value.